



Critical Care Therapy and Respiratory Care Section

Category:	Clinical
Section:	Clinical Monitoring
Title:	Hemodynamic Monitoring
Policy #:	03
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1.0. DESCRIPTION

1.1 Definition

Hemodynamic monitoring is the expert collection and analysis of qualitative and quantitative data of cardiopulmonary function. This monitoring includes clinical observation, the use of electrical, photometric, pressure transducing equipment, and other noninvasive devices, as well as the application of a number of intravascular catheters. Fluid-filled monitoring systems attach to intravascular catheters and are used for continuous invasive measurement of arterial and cardiac pressures. Periodic measurement of other pressure/flow and gas exchange parameters may also be performed.

This procedure will provide instruction in the use of invasive methods of hemodynamic monitoring in critically ill adult and pediatric patients. The proper procedures for assisting a physician with insertion of catheters used in hemodynamic monitoring are delineated. The safe monitoring and data collection of arterial blood pressure, central venous pressure, pulmonary arterial pressure, pulmonary capillary wedge pressure, cardiac output, and other derived parameters are explained here. Procedures and considerations specific to pediatric patients are *italicized*. Arterial blood collection from arterial catheters and mixed venous blood collection from pulmonary artery catheters is described in the CCTS Procedure for Collection of Blood for Analysis of Blood Gases, Acid-Base Status, and Oxygen-Carrying Capacity.

1.2 Indications

1.2.1 Arterial pressure monitoring

1.2.1.1 During manifestations of hemodynamic instability

1.2.1.2 For measurement of the hemodynamic response to therapeutic intervention, e.g., administration of vasoactive pharmacologic agents

1.2.1.3 For repeated arterial blood gas sampling

1.2.2 Central venous pressure monitoring

- 1.2.2.1 For assessment of intravascular volume status and venous return
 - 1.2.2.2 For administration of fluids and/or drugs
 - 1.2.2.3 For assessment of cardiac function
- 1.2.3 Pulmonary arterial pressure monitoring
 - 1.2.3.1 For diagnosis, management, and treatment of cardiopulmonary insufficiency
 - 1.2.3.2 For management and treatment of shock
 - 1.2.3.3 For assessment of pulmonary vascular function
 - 1.2.3.4 For assessment of cardiac function
 - 1.2.3.5 For cardiac pacing
 - 1.2.3.6 For diagnosis of lymphangitic carcinomatosis (See the CCTRCS Procedure for Collection of a Cytology Specimen from a Pulmonary Artery Catheter.)
- 1.3 Complications
 - 1.3.1 Bleeding or bruising at the catheter insertion site
 - 1.3.2 Hemorrhage or "bleedback" from loose pressure line connections, loss of pressure from pressure infusion bag, or catheter dislocation
 - 1.3.3 Air embolus during insertion, tubing changes, blood sampling, or drug infusion, or resulting from pulmonary artery catheter balloon rupture
 - 1.3.4 Thrombosis from blood clot at catheter tip with loss of distal perfusion
 - 1.3.5 Decreased blood flow distal to the catheter due to the size of the catheter within the vessel
 - 1.3.6 Vascular erosion
 - 1.3.7 Improper vascular placement due to tortuous vascular pathways
 - 1.3.8 Infection
 - 1.3.9 Neuromuscular injury at site of insertion
 - 1.3.10 Fluid overload from continuous infusion of flush solution (greater issue for pediatric patients weighing less than 20 kg)
 - 1.3.11 Pneumothorax or hemothorax during venipuncture for insertion of central venous catheters

- 1.3.12 Dysrhythmias attributed to central venous or pulmonary artery catheter migration or irritation of the myocardium
- 1.3.13 Perforation of cardiac structures due to catheter migration
- 1.3.14 Puncture or rupture of pulmonary artery during pulmonary artery catheter insertion or manipulation
- 1.3.15 Knotting, looping, or entanglement of a pulmonary artery catheter in the vessels or chambers of the heart.
NOTE: The distance from the internal jugular vein to the right ventricle is approximately 25 to 30 cm; to the pulmonary artery 40 to 45 cm; and to the wedge position 45 to 50 cm.
- 1.3.16 Pulmonary infarction or ischemia from prolonged wedging of pulmonary artery catheter balloon or embolization of a thrombus from the tip of a catheter.
- 1.3.17 Incorrect hemodynamic management due to poor data collection and analysis techniques

1.4 Precautions

- 1.4.1 Manipulations to indwelling catheters or related equipment should only be performed with gloved hands to avoid contact with potentially infectious (blood borne or other skin-to-skin transmission, i.e., hepatitis A) agents.
- 1.4.2 Care must be taken to ensure that pressure monitoring apparatus remains in good working order throughout monitoring to avoid false pressure readings, thrombus formation due to an inadequate flush solution volume, or “bleedback” due to loose or cracked connections or an inadequate pressure from the pressure infusion bag. Additionally, there should be no air in the pressure monitoring system(s) as this presents a potential hazard for air embolism and contributes to false pressure readings. Transducers must be maintained at the phlebostatic axis and successfully zeroed prior to data collection.
- 1.4.3 Pulmonary artery catheters should be monitored continuously for the potential of spontaneous or inadvertent wedging of the catheter. Catheters left in the wedge position for longer than two minutes may cause pulmonary ischemia or infarction.

- 1.4.4 In order to minimize the risk of acquiring false cardiac output data, it is imperative that the correct computation constant be used, and that injectates remain at the appropriate temperature.
- 1.4.5 Aseptic technique must be maintained during equipment setups, changes, and manipulations to minimize the risk of infection.
- 1.4.6 Appropriate pressure alarms should be maintained throughout monitoring to provide an alert to equipment malfunction or other adverse effects.
- 1.4.7 Positive pressure ventilation may falsely elevate pressure readings. It is imperative that analysis of pressure waveforms be performed in a consistent fashion. The pulmonary artery wedge pressure is especially susceptible to the effects of positive end expiratory pressure (PEEP). Failure to adequately account for this effect may lead to inappropriate fluid management. Additionally, wide variations in the a, c, and v waves call for close attention in analyzing the wedge pressure. Refer to the CCMD policy for specific instruction in measurement of the mean capillary wedge pressure.
- 1.4.8 Improper performance of the Dynamic Response Test may reduce the fidelity of the pressure transducer and over- or underestimate systolic or diastolic pressures.
- 1.4.9 Pediatric patients may be especially vulnerable to complications associated with invasive monitoring. Extreme care must be taken when flushing lines to avoid retrograde blood flow from overly vigorous flushing, to avoid the introduction of thrombus from the proximal stopcock while flushing, and to avoid fluid overload through the inadvertent administration of large amounts of flush volume. Insertion sites and distal extremities must be closely monitored for blanching in case of decreased blood flow due to an inappropriately large catheter or compression at the site.
- 1.4.10 The benefits of invasive monitoring must be carefully weighed against the potential complications. A number of risks present relative contraindications for pulmonary arterial monitoring, including: coagulation defects, prosthetic right heart valve, endocardial pacemaker, abnormal anatomy, pulmonary hypertension, and left bundle branch block.
- 1.4.11 Pulmonary artery catheters may migrate spontaneously, as the result of diuretic therapy, after patient coughing, or with patient position changes. Questions of pulmonary artery catheter position

should be resolved immediately including obtaining a chest radiograph when necessary. See 1.5.7. for further instruction.

- 1.4.12 Swan-Ganz catheters contain an electrical thermister that allow for thermodilution measurements. Any electrical conductor, such as this, within the body which has sufficient length can, in the presence of alternating magnetic fields, generate an electrical current. In the case of Swan-Ganz lines, it has been reported by Shellock et al. That the heat generated by this current can melt parts of the catheter. An additional, but more theoretical concern, is that the small electrical signals generated in the conductor could induce arrhythmias. A warning has been placed in several authoritative sources (Stark and Bradley textbook on MRI). **Therefore, MRI should not be performed in patients with pulmonary artery catheters, or in any patient with conductors entering the heart, including external and temporary pacing wires. For these patients, the pulmonary artery catheter needs to be temporarily removed for the MRI.**

1.5 Reactions and Interventions

- 1.5.1 If “bleedback” occurs during pressure monitoring, ensure that a pressure of 300 mm Hg exists from the pressure infusion bag, tighten or replace any loose or cracked connections, close stopcocks open to the patient, and/or ensure that adequate flush solution is being infused.
- 1.5.2 If swelling, blanching, discoloration, numbness, tingling, pain, weakened pulses, prolonged capillary refill time, or other signs of perfusion abnormalities are noted in a patient with an indwelling catheter, check the catheter for patency by first attempting to aspirate blood through the catheter, and then, if successful, flush the catheter. It may be necessary to manually flush the catheter using either a 0.9% NaCl or a heparinized 0.9% NaCl solution. **NOTE: If aspiration fails to produce a blood return, do not flush.** The catheter may need to be removed to avoid the potential for embolism from the catheter tip and/or distal ischemia. Consult the physician.
- 1.5.3 If hemorrhage from the catheterization site is noted, apply direct pressure, and check for catheter dislocation.
- 1.5.4 Fluid-filled monitoring systems must be assessed for optimal function prior to data collection and analysis. An optimally functioning system is free of leaks, bubbles, clots, kinks, obstructions, electrical problems, and improper catheter placement

or position. It must also have good blood return and infuse with ease

1.5.5 If dysrhythmias are noted during a patient position change or manipulation to the catheter, return to the former position and observe. If dysrhythmias persist, consult the physician. It may be necessary to obtain a chest radiograph to confirm the catheter position.

1.5.6 Rupture of a pulmonary artery catheter balloon must be noted and health care professionals advised against further use of the balloon. Suspect a ruptured balloon if:

1.5.6.1 There is blood in the return syringe volume.

1.5.6.2 The balloon does not return air to the syringe when the syringe is released.

1.5.6.3 No resistance is felt during inflation of the balloon.

1.5.6.4 The pulmonary arterial pressure waveform persists after an attempt at inflation.

The risk of a ruptured balloon may be minimized by adhering to the manufacturer's specifications for maximum inflation volume (1.5 ml for 7 Fr and 8 Fr catheters and 1.25 ml for 5 Fr catheters), avoiding inflating the balloon with fluid, and avoiding aspirating the air volume from the balloon.

1.5.7 Backward or forward migration of a pulmonary artery catheter may cause lethal consequences for the patient including dysrhythmias, damage to intracardiac structures, or pulmonary infarction. Suspect a migrated pulmonary artery catheter if:

1.5.7.1 Wedge is not achieved with the full inflation volume of the syringe (balloon rupture must be ruled out) or the catheter wedges with a minimal amount of air (less than 1.25 ml for a 7 or 8 Fr catheter; less than 1.0 ml for a 5 Fr catheter).

1.5.7.2 The pulmonary arterial waveform shows an “overwedge” pattern before or after balloon inflation.

1.5.7.3 The pulmonary arterial waveform is dampened.

1.5.7.4 The signal quality indicator (SQI) on a fiberoptic pulmonary artery catheter indicates an increasing (worsening) number.

1.5.7.5 A pulmonary arterial waveform has become a right ventricular waveform. If the catheter has continuous cardiac output monitoring capabilities, all monitoring will cease, and the Vigilance monitor will display a warning message “Check thermal filament position.”

In all of these situations, the physician should be notified immediately. In the event of life-threatening complications, remain with the patient, and perform rescue care as needed.

If the catheter has to be repositioned by the physician, a pulmonary artery wedge pressure tracing must be obtained, labeled, and posted in the bedside chart. Documentation of the repositioned catheter must include the depth of insertion and that the catheter is in the “locked position.”

*For further aid in the troubleshooting of blood pressure monitoring systems, refer to **6.0. REFERENCES**.

2.0 EQUIPMENT AND MATERIALS

- 2.1 Appropriate apparel for aseptic technique and universal precautions which includes sterile gowns and gloves, caps, masks, and goggles as appropriate for the level of care provided by each member of the health care team involved with the procedure (See the CCMD Universal Precautions Policy).
- 2.2 Cardiorespiratory monitor, printer, and ECG/Pressure modules
- 2.3 Pulse oximeter
- 2.4 Appropriate labels for flush type (0.9% NaCl or heparinized 0.9% NaCl) and type of pressure line
- 2.5 Arterial line insertion
 - 2.5.1 Arterial catheter kit: 18 gauge kit for femoral arterial cannulation, 20 gauge kit for other adult sites, *22 gauge kit for pediatric cannulation.*
 - 2.5.2 Betadine
 - 2.5.3 Gauze 4 x 4s
 - 2.5.4 Wrist immobilizer (for radial or ulnar arterial lines)
 - 2.5.5 1% lidocaine
 - 2.5.6 25 gauge needle and syringe
 - 2.5.7 One-inch tape
 - 2.5.8 Sterile dressing (per nursing)
 - 2.5.9 Optimally functioning fluid-filled monitoring system (See Procedure.)

2.5.10 *For pediatric patients under 20 kg, 0.9% NaCl flush syringes (See the CCRCTS Procedure for Collection of Blood for Analysis of Blood Gases, Acid-Base Status, and Oxygen Carrying Capacity.)*

2.6 Pulmonary artery catheter insertion

- 2.6.1 Pulmonary artery (PA) catheter kit: Sizes available include 5 Fr (*pediatric up to approximately 20 kg*), 7 Fr (*pediatric greater than 20 kg*), and 8 Fr.
- 2.6.2 Introducer kit: 6 Fr for 5 Fr PA catheter, 8 Fr for 7 Fr PA catheter, 8.5 Fr for 8 Fr PA catheter.
- 2.6.3 10D Special Procedures kit
- 2.6.4 Betadine
- 2.6.5 Gauze 4 x 4s
- 2.6.6 Sterile dressing (per nursing)
- 2.6.7 Introducer pump infusion setup (per nursing)
- 2.6.8 Optimally functioning fluid-filled monitoring systems for pulmonary arterial and central venous pressure monitoring (See Procedure.) *In the pediatric patient weighing less than 20 kg, this includes the use of a 3 ml/hr Intraflo[®] device.*
- 2.6.9 Thermodilution cardiac output cable with module
- 2.6.10 Ice bucket filled with ice
- 2.6.11 5% dextrose in sterile water injectate kits (Thermoject) for bolus thermodilution cardiac output
- 2.6.12 Blood gas analysis syringes and waste syringes
- 2.6.13 Gauze 2 x 2s
- 2.6.14 Vigilance monitor with catheter interfacing cables (when available)
- 2.6.15 For femoral insertion: Siemens Siremobil Fluoroscopy Unit, lead aprons for the caregivers in attendance, and a lead barrier for gonadal protection for the patient
- 2.6.16 Appropriate size manual resuscitator, mask, and intubation box

2.7 Monitoring of central venous pressure via a central venous catheter (Nursing usually assists with the insertion of these lines.)

2.7.1 Optimally functioning fluid-filled monitoring system

3.0 PROCEDURES

3.1 Assistance with insertion of invasive lines for hemodynamic monitoring purposes

3.1.1 Assemble all equipment and materials as described in 2.0

EQUIPMENT AND MATERIALS:

3.1.1.1 The choice of flush solution for the maintenance of patency of invasive lines is based on the patient's platelet count.

Patients with platelet counts less than 100,000 mm³ or who demonstrate a decrease in the number of platelets by 50% after the initiation of monitoring should receive only 0.9% NaCl flush solution. If thrombocytopenia is not a problem, a solution of heparin in 0.9% NaCl should be used. *NOTE: Because of the risk of thrombus formation in small catheters, pediatric patients less than 20 kg should **always** receive heparin flush regardless of platelet status.*

3.1.1.2 Assemble the fluid-filled monitoring system(s) per the manufacturer's instructions, and run the flush solution through all lengths of the tubing, stopcocks, and side ports so as to remove all air from the system. Place "dead end" caps on all of the ports to maintain asepsis.

3.1.1.3 Label the flush bags and lines with the appropriate label, and date and time of setup.

3.1.1.4 Pump up the pressure infusor bag(s) to 300 mm Hg. *For pediatric patients less than 20 kg, the flush solution will be run through a microrate infusion pump for precise control of volume and pressure. Assist the nurse as needed using a 3 ml/hr flush device and Burretrol tubing.*

3.1.1.5 Attach the monitoring cable(s), and label the pressure waveform(s) on the cardiorespiratory monitor.

3.1.1.6 Level the transducer(s) to the level of the patient's phlebostatic axis (midaxillary line in the supine position), and zero the line(s).

3.1.1.7 For bolus thermodilution cardiac output, place five 5% dextrose solution injectates in the ice, fill the reference test tube with water, and place the reference tube (with reference temperature probe inserted) in the ice also.

3.1.1.8 For use of the Vigilance system: Plug the monitor into a grounded AC power outlet, and turn the monitor ON. Connect the interfacing cables, including the optical module

into the front of the monitor. Allow 20 minutes for optical module warm-up before beginning continuous monitoring.

- 3.1.2 Insertion of a pulmonary artery catheter: After the introducer has been placed successfully, prepare for insertion of the catheter as follows

NOTE: The optical module on the Vigilance catheter should be calibrated prior to flushing the catheter. Instruct and assist the physician to connect the SvO₂ monitoring port on the catheter to the optical cable from the monitor. Perform the in vitro calibration.

- 3.1.2.1 From the special procedures kit, the physician will secure the flush lines for attachment to the pulmonary artery distal port (yellow) and the central venous proximal port (blue). Assist with the flushing of all **three** ports of the catheter given these two flush lines. A systematic approach to the flushing of the ports is optimal in order to prevent errors in labeling and monitoring of the three ports/pressures. The following procedure will ensure proper labeling/monitoring and minimize confusion between the therapist and physician:

- 3.2.1.1.1 Instruct the physician to attach a stopcock followed by a flush line to the auxiliary (clear) port of the catheter. With the stopcock in the open position (arrow points perpendicular to the catheter), flush the line until flush solution from the right atrial distal port of the catheter is observed using the transducer/flush line setup labeled for central venous pressure (CVP) monitoring (blue label).
- 3.2.1.1.2 Instruct the physician to remove the flush line from the auxiliary port while maintaining the stopcock there and turning the stopcock off to the catheter (arrow points toward the catheter). Instruct him/her to then secure the same flush line with another stopcock on the right atrial proximal port (blue for CVP). The flush line requires no change of location by the therapist at this step. Flush the catheter until solution is observed at the right atrial proximal port on the catheter.
- 3.2.1.1.3 Instruct the physician to attach the second flush line to the pulmonary artery distal port (yellow) using a third stopcock. Attach the opposite end of this flush line to the transducer/flush line setup labeled for pulmonary artery pressure (PAP-yellow label) monitoring. Flush the line

until flush solution is observed from the tip of the catheter.

- 3.1.2.2 Ensure that the physician inflates the balloon to check for patency and symmetry.
- 3.1.2.3 Ensure that the physician attaches the sleeve for post-insertion manipulation of the catheter to the hub of the catheter.
- 3.1.2.4 Ensure that the pressure monitoring lines are labeled correctly (through observation of waveform changes with physical movement of the catheter), and that transducers are level with the patient's phlebostatic axis and zeroed. Access the pulmonary arterial waveform on the cardiorespiratory monitor utilizing the 0 to 30 mm Hg pressure scale. Activate the printer for a continuous printout of the catheter insertion procedure.
- 3.1.2.5 Ascertain that the catheter is positioned correctly within the pulmonary artery by observation of successive pressure waveforms exemplifying its position in the right ventricle, pulmonary artery, and finally in a wedged position (while the balloon is inflated).
- 3.1.2.6 For CCO/SvO2 monitoring: Connect the interfacing cables to their proper connections on the catheter. To begin CCO monitoring, press **CCO**. The monitor will now display "Collecting CCO data" until sufficient data have been collected (approximately three to six minutes) before displaying a CCO value. To begin SvO2 monitoring, press **SvO2**, and then **IN VIVO CALIBRATION**. Press **DRAW**, and obtain a mixed venous blood sample for co-oximeter analysis of SvO2 and hemoglobin. Enter the lab values using **CURSOR**, then press **CAL**. After the monitor has completed its calibration, the current SvO2 will be displayed.

NOTE: SvO2 calibration must not be performed if the Signal Quality Indicator is greater than or equal to three. Refer to the Troubleshooting Guide at the end of this procedure or the Vigilance Operator's Manual for specific instruction regarding optical signal quality problems or problems specific to CCO monitoring.

NOTE: A change in hemoglobin of **1.8 g/dL** or greater necessitates an update in the recorded hemoglobin within the monitor. Also, a calibration should be performed at least once every 24 hours.

- 3.1.3 Insertion of all lines will be performed by physicians only. Be prepared to assist with retrieval of additional supplies,

fluoroscopy, or other requests. Be alert and ready to respond to complications of insertion, i.e., ventricular ectopy.

3.2 Monitoring and data collection

3.2.1.1 To ensure the accuracy of monitored pressures, a quality check of the system must be performed prior to data collection. Observe the pressure being exerted on the system via the pressure infusor bag and refill to 300 mm Hg if needed, perform a Dynamic Response Test, and ensure a safe and comfortable attachment of the catheter to the patient. The Dynamic Response Test is performed by opening and rapidly closing (“snapping”) the fast flush device. A square wave followed by oscillations (“ring”) are seen on the monitor. In an optimally functioning system, the initial upstroke is rapid and continues in a flat line until the release causes the oscillations. One or two oscillations in 0.12 seconds with a quick return to baseline is considered minimal ringing. All components of the arterial waveform, such as the dicrotic notch, must be clearly present with minimal ringing to ensure a properly dampened system. See also “Physical Principles Involved in Pressure Monitoring Systems” at the end of this procedure.

3.2.2 Obtain a hard copy of all pressure waveforms being monitored at least once per 12-hour shift. A hard copy should also be obtained whenever a line is inserted, a specific request has been issued per the physician, the line is repositioned, or there is a question as to the accuracy of hemodynamic data. Optimally, these printouts will be obtained on the 0 to 30 mm Hg scale for CVP, PAP, and PCWP to maintain consistency of analysis. However, high pressures may necessitate the use of the 0 to 60 mm Hg scale i.e., pulmonary artery diastolic pressures greater than 30 mm Hg. These hard copies must be retained in the patient's bedside chart, and must include documentation of the patient's name, date, time, and the pressure measured with the scale and values clearly indicated. All transducers should be leveled and zeroed prior to printing hard copies.

3.2.3 Data collection for a hemodynamics "full set":

3.2.3.1 Obtain hard copies for arterial, central venous, pulmonary artery, and pulmonary artery wedge pressures. These are best obtained in a supine, flat position as tolerated by the patient. Wedge pressure measurements are optimally determined from a printout of five consecutive respiratory cycles.

3.2.3.2 Bolus thermodilution cardiac output: If a continuous cardiac output catheter (Baxter-Edwards Swan-Ganz CCO/SvO₂/VIP catheter) is being used, stop CCO collection via the Vigilance monitor, and disconnect the Vigilance monitor from the catheter's thermistor connection. Connect the Hewlett Packard cable to the catheter's thermistor connection. Ensure that the proper computation constant for measurement of the cardiac output is entered into the cardiorespiratory monitor (See the manufacturer's specification for the constant for the catheter size and model, and the injectate volume required.). Obtain an average for the cardiac output using the manual thermodilution method; *use a 10 ml injectate volume for adults and children greater than 50 kg and five ml for patients less than 50 kg*. Three data points must agree with each other to within 10 percent of the median. If not, perform five maneuvers, discard the lowest and the highest values, and average the remaining three. Resume continuous cardiac output monitoring.

NOTE: While the Vigilance CCO system is being used, the following situations necessitate the determination of the cardiac output via the bolus method: (1) The Vigilance monitor has malfunctioned as evidenced by an absence of data for the cardiac output or an error message indicating the inability to process data, (2) the monitored cardiac output is not consistent with the patient's clinical assessment, and (3) there is a scarcity of Vigilance monitors despite the use of the CCO catheter.

3.2.3.3 Obtain arterial and mixed venous blood for blood gas analysis. When using the Vigilance SvO₂ system, analysis of mixed venous blood is only necessary when calibrating the monitor (i.e., once every 24 hours) or when specifically requested by the physician.

3.2.3.4 Compute the values for mean systemic and pulmonary arterial pressures, cardiac index, systemic vascular resistance, and systemic vascular resistance index. Record all of the data from steps 3.2.2.1. through 3.2.2.4. on the CCTRCS Patient Daily Sheet and the bedside nursing flowsheet.

3.2.3.5 Report any critical results to the physician.

3.2.4 Data collection for a new pulmonary artery catheter insertion must include in addition to all the above (3.2.2.1. through 3.2.2.5.) a recording of the right ventricular end diastolic pressure (RVEDP), and a hard copy must be posted in the patient's chart. Record this pressure on the Patient Daily Sheet and the nursing flowsheet as

well. An RVEDP which compares to values for the central venous, pulmonary artery diastolic, and pulmonary capillary wedge pressures to within five mm Hg may be indicative of cardiac tamponade.

4.0 POST PROCEDURE

- 4.1 Ensure that five additional injectates are inserted into the ice bucket and replace the ice as needed.
- 4.2 Ensure that the proper pressure waveforms are displayed on the monitor after manipulations to the flush lines or catheters and be certain that alarms are reactivated.
- 4.3 Return the patient to a comfortable position after data collection and relevel all transducers.
- 4.4 Report the total volume of fluid used for the cardiac output determination to the nurse.
- 4.5 Change flush bags daily and change flush lines and transducers every 72 hours as per the CCTRCS Changing of Equipment Policy. Nondisposable items of hemodynamic monitoring should be wiped down with alcohol after use and before storage.
- 4.6 Inspection and testing of the system is performed once per shift at a minimum. This is done to detect any signs of degradation of signal, to ensure optimal functioning of the system, and to provide maximal patient safety and comfort. This includes a Dynamic Response Test, and general inspection of the patient, catheter's "locked" position, lines, and displayed waveform. Investigate any suspicious findings and troubleshoot as appropriate.

5.0 DISCONTINUATION OF ARTERIAL CATHETERS

5.1 Arterial Catheters

- 5.1.1 Arterial catheters may be removed by the physician, nurse, or a credentialed respiratory therapist.**
- 5.1.2 Following discontinuation of the catheter, pressure must be applied to that area using a sterile 4x4 gauze pad until it is determined the bleeding has ceased.**
- 5.1.3 Verification of the cessation of bleeding from the site must be determined through direct visualization.**
- 5.1.4 Once the care provider has determined that the bleeding has stopped, the care provider will apply a band-aide to that area and will continue to monitor the area for an hour after withdrawal of catheter.**

5.2 Central Lines

5.2.1 Central lines may only be removed by a nurse or physician.

5.3 Pulmonary Artery Catheters

5.3.1 Pulmonary artery catheters may only be removed by a nurse or physician.

6.0 CHARTING AND REPORTING

- 6.1 Record all data generated through hemodynamic monitoring on the Patient Daily Sheet and on the nursing flowsheet. Post hard copies of all pressure waveforms in the bedside chart at least once per shift.
- 6.2 Report all information pertinent to the patient's hemodynamic status, as well as that information pertinent to data collection, e.g. patient position, catheter's "locked" position, tolerance, etc., to the next shift staff.
- 6.3 Record line insertion dates, flush solution type, and flushline and transducer changes on the line board in the STAT Lab.
- 6.4 Chart removal of the arterial catheter on the "Continuous Ventilation Flow Record" if performed in the MICU or in MIS if removal occurs outside of the MICU. Documentation should include the date/time of removal, the amount of time pressure was applied, the integrity of the site, and your name and credentials.

7.0 REFERENCES

- 7.1 Oakes D. Hemodynamic monitoring: a bedside reference manual. Old Town, Maine: Health Educator Publications, 1993.
- 7.2 Darovic GO. Hemodynamic monitoring: invasive and noninvasive clinical application (2nd ed.). Philadelphia: Saunders Publishing, 1995.
- 7.3 Ahrens TS, Taylor LA. Hemodynamic waveform analysis. Philadelphia: WB Saunders Co., 1992.
- 7.4 CCTRCS Changing of Equipment Policy.
- 7.5 CCMD Measurement of Mean Pulmonary Capillary Wedge Pressure Policy
- 7.6 CCMD Transducer Change Policy
- 7.7 CCMD Universal Precautions Policy

- 7.8 SpaceLabs Operations Manual: Module #90470 Multi-parameter module
- 7.9 SpaceLabs Operations Manual: Module #90404 Cardiac output/pressure module
- 7.10 *Vigilance* Operator's Manual
- 7.11 10D Critical Care Nursing Policy "Use of the MicroRate Infusion Device on Hemodynamic Lines"
- 7.12 CCMD Policy "Vascular Access in Pediatric Patients"

SIGNATURE: _____
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